ABSTRACTS OF THE SCIENTIFIC PAPERS

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ABSTRACTS OF SCIENTIFIC PAPERS AND TEACHING TUTORIALS

For participation in the competition, a total of 30 abstracts of peer-reviewed scientific papers are presented, distributed as follows:

- Habilitation work (monograph) – **1 pc**;
- Scientific publications – **24 pcs**;
- Teaching tutorials – **3 pcs**;
- Registered utility models – **2 pcs.**

The scientific publications submitted for participation in the competition are divided into three groups:

- **The first group [A] is a habilitation work (monograph) on the topic: Finishing operations by sliding friction at machining of holes**

- **The second group [Б] and [В]** presents a total of 27 scientific papers, of which 24 are scientific publications, of which 8 are independent [Б8], [Б9], [Б10], [Б14], [Б15], [Б16], [Б18], [Б19], [Б20], [Б21] and 3 teaching tutorials. Of which:
  - Reports in international scientific conferences abroad [Б1], [Б2], [Б3], [Б4] – 4 pcs;
  - Reports in international scientific conferences in Bulgaria [Б5], [Б6], [Б7] – 3 pcs;
  - Papers in international scientific journals abroad [Б8], [Б9], [Б10], [Б11], [Б12], [Б13], [Б14], [Б15] – 8 pcs;
  - Papers in international scientific journals in Bulgaria [Б16], [Б17], [Б18], [Б19], [Б20], [Б21] – 6 pcs;
  - Papers in scientific journals in Bulgaria [Б22], [Б23], [Б24]– 3 pcs
  - Teaching tutorials – 3 pcs;

Thematically, the works from group [Б] are systematized in the following areas:

1. Designing of combined tools for machining of holes - [Б3], [Б4], [Б5], [Б7], [Б15], [Б16], [Б17], [Б18], [Б19], [Б24].
2. Determination of constructive and geometrical parameters of cutting tools, in particular for machining holes - [Б6], [Б8], [Б9] [Б10].
3. Methods, mathematical and simulation models for studying the behavior of milling tools in the shaping of machined surfaces - [Б1], [Б2], [Б13], [Б14].
4. A study of the processes of chip formation in single-edge drills - [Б11], [Б12]
5. Application of software products for design and analysis of processes, parts and equipment - [Б20], [Б21], [Б23].
6. Methodology for determining the characteristics of regular microrelief - [Б22].

Thematically, the works from **group [В]** are in the following areas:

- Manufacturing Technologies;
- Technological equipment;
- Cutting tools.

- **The third group [Г]**, presents two registered utility models - [Г1], [Г2]

Thematically, the works from **group [Г]** are in the following areas:

- Cutting tools and cutting of the materials.

ABSTRACTS

Abstract of habilitation work (monograph) from group [A]

Abstract of habilitation work (monograph)

Avramova T., Finishing operations by sliding friction at machining of holes, Color Print, Varna, 2019, page 108, *ISBN 978-954-760-490-2*

The machining of the holes to which there are high requirements, such as the holes of the hydraulic cylinders, is a specific technological operation, the implementation of which required the creation of special tools, devices and equipment. The technology of machining these precise holes has a number of specific features, which distinguishes it from the technologies in general mechanical engineering.

There is a direct relationship between the quality parameters of the treated surfaces and their performance characteristics. The functional analysis of the behavior of the surfaces gives the need to obtain reduced roughness and increased accuracy of the geometric parameters of the holes with increased requirements.

The solving the problem related to increasing productivity and management and meeting the quality parameters (high accuracy of shape and size and low roughness of the treated surfaces) lies in the application of a tool with combined impact, performing several operations simultaneously - boring holes and subsequent smoothing by plastic deformation and a tool for smoothing surfaces by sliding friction.

The first part of the monograph work is a brief overview of the theories of chip formation and the forces acting on the face of the tool. This is a slight introduction to the field and acquaintance with the many factors influencing the shape of the chip. For easier presentation and perception of acting forces on the face of the tool, the corresponding mathematical dependences are shown.

The second part of the monograph begins with an introduction to the problematic of monographic work. This part presents a methodology for determining the chip length compression ratio, which is a mathematical dependence, the conversion of which leads to obtaining the mentioned factor. In a similar way is approached to the presented methodology for determining the coefficient of plastic deformation. After the presented methods is shown a theoretical model of the movement of the chip. With the introduction in production of drills with disposable hard metal inserts (DHI), the cutting speeds have practically increased. These higher speeds, in turn, imply the removal of larger amounts of material in the form of chips per unit time. Graphically and mathematically, the movement of the chips on the face of the tool, the winding of the chips and determining the angle of its displacement are presented.

Logically, from the presented into the second part, the third part is separated for chip breaking and cooling of the cutting zone during machining of holes. A graphical representation of the chip curvature radius is done, which is used to derive the mathematical dependencies for determining the chip curvature radius. The determination of the magnitude of the critical radius of curvature of the chip is described mathematically. Based again on the mathematical dependencies is shown determining the distance from the cutting edge of the insert, at which the chip breaking element must be placed. This part presents theoretical and experimental studies. According to the theoretical studies for the chip length compression ratio Ka in the more plastic materials this ratio is higher as Ka reaches up to 9 at high speeds (above 180 m/min) when cutting Duraluminium (AlCu4Mg1) and accepts values 4-6 at low cutting speeds (50 -150 m min). According to the theoretical studies of the coefficient of plastic deformation, it can be seen that at a small rake angle γ = (2°-4°) in the range of the high cutting speeds V = (160-280 m/min) the relative plastic deformation remains almost constant. This can be explained as follows: at a smaller rake angle, the average coefficient of friction on the face decreases, and this leads to a decrease in the degree of plastic deformation. The experimental results are presented, which are very well illustrated by the corresponding graphical dependences and numerical expressions. They make it easy to make a comparative analysis of the results for the various studied material.

The fourth part is devoted to the influence of the cutting coolant (cutting fluid) on the processes of crushing and removal of chips. In this part the substantiation and confirmation of the results obtained in the previous part is made, namely the need for the use of coolant.

The fifth part is focused on the guiding elements of tools for machining holes, which in the following parts of the monograph occupy a significant part in the new proposed designs of tools for machining holes. The previously known guiding elements are presented in order to prove the lack of the proposed in the next part. A known construction was used for them and it was modified to achieve the desired impact on the treated surface.

The sixth part is conditionally divided into two parts. The first presents the construction of a tool for smoothing holes. The construction of the tool is described and illustrated, as well as its functionality. The construction of the guide-smoothing elements is shown, which in their work must lead to the achievement of low roughness of the machined hole. The derived mathematical dependencies for determining the forces with which the guide-smoothing elements act on the treated surface are shown. Shown is the connection between the influencing forces and the angles at which the guide-smoothing elements are placed trough of graphical and numerical proofs. In the second half of this part is shown the design of a combined tool for widening holes. As in the first half, the construction and functionality of the tool are described. Here is presented the construction of the guide-smoothing elements, which have the corresponding orthogonal clearance for performing not only guiding the tool through the hole, but also for cutting, ie. for removing fine chip. The values of the components of the cutting force for different lengths of the cutting edge of the guide-smoothing element are presented graphically and numerically. The results of simulation tests of the tool are also shown graphically, which show that at the displayed values of the components of the cutting force the tool will work normally.

The seventh part presents summarized results from experimental studies of real samples obtained by the two tools presented in the sixth part. Relevant studies have been made for roughness, deviation from dimensional accuracy, deviation from roundness, deviation from cylindricity, as well as studies of the microhardness of the treated surface, which shows the in-depth studies of the issue posed in the monograph. The results of the studies prove that the proposed designs for finishing processes for the machining of holes with high requirements, and not only, are working and applicable in production processes.

Abstracts of papers from group [Б]

Abstract of paper **[Б1]** from list of publications

*Lefterov E., **Avramova T.**, Ianasi C., Kinematic Schemes of Cutting In Milling, 11th Symposium Durability and Reliability of Mechanical Systems SYMECH 2018, Rânca, Gorj, Fiability and Durability Journal, Editura "Academica Brancusi", Targu-Jui, Issue 1 (2018), pp.161-166, ISSN: 1844-640X*

The machining of the parts by cutting is based on certain movements performed by the tool relative to the workpiece. In order to perform a particular processing, the executive units of the respective machine need to transmit to the tool and the workpiece such movements that at the end of the working process result in a part with a certain accuracy of the shape and dimensions and the quality of the treated surface. In this sense, the movements of the tool and the workpiece for each particular processing are carried out according to a strictly regularity, observance of which is of decisive importance for the construction of a particular method of machining and if it is required for a particular processing machine. Milling is one of the most productive cutting processes and therefore, the present work analyzes the used kinematic cutting patterns.

The main concepts and definitions used in the paper are mainly taken up by the terminology of Acad. Grenovski GI, an active member of the Latvian Academy of Sciences.

Based on the classification of the basic kinematic schemes (representing the movements that are performed) in milling, made by Herbert Ivanovich Granovski, mathematical dependencies (depending on who the two elementary movements belong to - rectilinear and rotational) are derived, which describe the trajectory of the relative working movement of a point on the cutting edge of the tool.

Studies have been done through simulation modeling using the SolidWorks software. The results for the change of the clearance angle α at certain values of angle φ for milling cutter diameters D = 15 mm, 22 mm, 36 mm, 50 mm, at R = 25 mm, K = 7 have been obtained. The parameter K represents the position of a certain point on the cutting edge.

Based on the derived mathematical dependencies, theoretical and simulation study, the following conclusions can be made:

1. In planar milling trajectory of the relative working motion is entirely dependent on the position of motion A (Figure 1), in each case the tool performs rotational movement.

2. The trajectory of the relative working motion is a planar curve, the variants are extended and shortened cycloid.

3. A suitable method for study the geometric parameters of the milling cutter is the virtual modeling and simulation approach describing the real movements of the milling cutter.

4. The change of the clearance angles at different points of the cutting edge of milling cutters with diameters D = 15, 22, 36, 50 mm is minimal and on the efficiency of the tool is influenced by the different cutting speed from the center towards the periphery.

Abstract of paper **[Б2]** from list of publications

*Lefterov E., **Avramova T.**, Milling of Complex Surfaces, 11th Symposium Durability and Reliability of Mechanical Systems SYMECH 2018, Rânca, Gorj, Fiability and Durability Journal, Editura "Academica Brancusi", Targu-Jui, Issue 1 (2018), pp.167-172, ISSN: 1844-640X*

Milling tools can perform processing on kinematic schemes classified by Acad. D. I. Granovsky from IV to VIII group. There is clearly a need for analyzing of principle kinematic schemes of cutting (PKSC) described by the motions different from one rotational and one rectilinear motion, which allows processing only planar surfaces.

To perform the machining of recessed and convex rotating surfaces, PKSC with two uniform rotational motions can be used A and B operating in the coordinate plane YOZ of the spatial coordinate XYZ system. The following two variants are of interest to the practice:

- Variant I – the two equal motions A and B have the same direction and ratio between their angular velocities $i = \frac{\omega_A}{\omega_B} = 0{,}003$. Furthermore, motion A belongs to the tool and the uniform rotational motion B of the workpiece. The two motions in the given direction can be imitated by the rolling of a circle on another one making contact.
- Variant II – both regular and rotating motions A and B have opposite directions and the ratio between the angular velocities i=0,005. Motion B belongs to the tool, and motion A of the workpiece. Both motions can be imitated as a rolling of two circles without sliding in the direction indicated and external contact.

For both variants, mathematical dependences are derived, describing the relative trajectory of a point on the cutting edge of the tool and respectively determining its type.

At present, most machining of CNC machines is performed according to the kinematic scheme 701 PKSC from the classification of G.I. Granovsky. This PKSC is composed of two uniform rotational motions A and B and a rectilinear uniform motion C. Depending on who performs these motions, the tool or the workpiece, the following two variants are of practical interest:

- Variant I – the uniform rotational motion B belongs to the tool, and the motions A and C to the workpiece. Moreover, A and B have opposite directions. In this case, the uniform rotational motion B determines the main motion of the cutting, A - the feeding, and C is an auxiliary one. The ratio of peripheral speeds is recommended $\varepsilon = \frac{V_A}{V_B} \approx 0{,}005$, because there is no kinematic connection at the CNC machines.
- Variant II – motions A and B have the same direction. The rotational A and rectilinear C uniform motions belong to the tool and the uniform rotational motion B of the workpiece. The peculiarity of this variant consists in the fact that neither rotational motions A and B are not identified with the motion of cutting. The latter is the result of the two elementary rotational motions A and B. In this case C is a feeding motion. At K<r and $\frac{\omega_A}{\omega_B} \geq 2$ the equation of the trajectory of the relative working motion at a point of the cutting edge of the tool is a screw shortened hypocycloid with an elliptical outline.

And in these two variants, mathematical dependencies are derived, describing the relative trajectory of a point on the cutting edge of the tool and determining its type.

In conclusion, the following can be summarized: the analysis of PKSC provides specific information on the shaping of individual surfaces of the workpiece, and allows to recommend the most appropriate strategy for production; the design of the shape and the number of cutting parts of the tool are indissolubly linked to the selected PKSC; choosing PKSC with more than two elementary motions significantly increases the productivity of the milling process; when building a particular method of treatment should be determined geometric parameters of the tool in accordance with the nature of the trajectory of the relative work motion.

Abstract of paper **[Б3]** from list of publications

Avramova T.G., *Lefterov E.L., Regarding the strength calculations of complex combined tools, International Conference - Modern Technologies in Industrial Engineering (ModTech) 2018, IOP Conference Series: Materials Science and Engineering, ModTech 2018, Vol. 400, 022005 (2018), pp. 1-7, doi:10.1088/1757-899X/400/2/022005*

In the modern machining, combined tools for machining holes with sequential impact are used. The first part of the tool is cutting and the second part impact by plastic deformation. In practice, the second impact is achieved either by sliding friction or by friction during rolling.

The approach presented in the article for strength calculations of the individual parts of combined tools for sequential impact is applied in the producing of the combined tool shown in the article for simultaneous machining of holes by chip removal and plastic smoothing. Normal operation of the machining tool is not permitted if residual deformations occur, as the machining quality indicators will be violated. This also applies to the influence of the elastic deformations of the individual elements, but without compromising the strength of the technical system as a whole.

The approach developed in the presented article includes by means of relevant mathematical equations determination of the safety coefficients and strength conditions of the individual parts of combined tool for sequential impact, which also takes into account the stress concentrators (graphically atre shown the most common stress concentrators) and determines the stress concentration factor.

As a summary and conclusions of everything shown and developed in the paper it can say the following:

1. For the correct strength calculation of complex design of tools, it is necessary:
   - Detailed analysis of load on individual elements;
   - Accurate determination of the nature of the load;
   - Using accurate results are cutting forces, friction forces, and other.
2. Strength studies must necessarily pass through reporting of stress concentrators abounding in the design due to the complexity of the load patterns.
3. Simplifying load patterns using the principles of mechanics reduce the authenticity of the results and make them in most cases unsuitable.
4. When conducting simulation analyzes using CAE design systems directed at cutting tools, the places leading to inaccuracies of the results obtained are the connections and contacts between the individual elements of the design.

Abstract of paper **[Б4]** from list of publications

Avramova T.G., *Lefterov E.L., Machining of Internal Cylindrical Surfaces with Adjustable Tool, 12 International Conference Interdisciplinarity in Engineering INTER-ENG 2018 - Tîrgu-Mureș, Elsevier's Procedia Manufacturing Journal, Vol. 32, (2019), ISSN: 2351-9789, pp. 29-35, https://doi.org/10.1016/j.promfg.2019.02.179*

This paper shows a newly developed design of an adjustable tool for smoothing holes with three deforming elements, working by the method of friction by sliding. The change of contact forces is achieved in three ways: by changing the angle of mutual arrangement; by changing the area of the smoothing elements; by changing the diameter of location of the smoothing elements.

The tool consists of a cylindrical body, ending with a conical or cylindrical tail to which are mounted three guide-smoothing elements. The tool body is a thick-walled tube on which a stepped section is machined on which the three smoothing elements are mounted. They are sectoral parts that have three contact surfaces. One element is stationary and the other two may be moved relative to it by channels made in the cylindrical forming line. The three modules are fixed with two screws each and a counter body. The coolant fluid is fed either through the center hole of the tool or in the gap between the body and the machined hole. The movable guiding elements are cylindrical forming, contacting the body of the tool on the inner surface, and the outside is in contact with the hole and by it the smoothening is performed.

The machining is carried out at the following kinematic schemes:

- Rotary and rectilinear motion of the tool;
- Rotary motion of the workpiece and rectilinear motion of the tool.

The use of different height elements allows the machining of holes of different diameter, but using different width and length smoothing inserts creates different forces of deformation.

Experimental studies have been made that are the basis for the initial determination of the normal forces in the guiding and smoothing elements. The theoretical research is made on the basis of mathematical dependencies derived by the author to determine the forces arising in the smoothing-guiding elements depending on the angle at which they are located.

By analyzing the results obtained, the following conclusions can be drawn:

- By maintaining an approximately constant torque of 30 N.m and a friction coefficient μ = 0.25, forces F_2 and F_3 change significantly;
- With the increase in diameter of the machined hole F_2 and F_3 decrease, which is explained by their mutual influence, looking at the spatial force system described by equations (1) and (2);
- The negative signs of the F_2 forces result from the positioning of the guiding elements in the pre-selected coordinate system;
- The results obtained show that the proposed tool allows to be adjusted and obtain different influence forces in the individual guides, which allows to work with different "tightening" (difference between the diameter of the opening and the circumscribed circle around the guides);
- At large diameters (D = 110 mm) and torque reduction at 25 Nm, the force F_3 changes its sign by striving to peel off the guide from the machined hole, which is removed by changing the tightening and using other angles of arrangement of the guides.

Abstract of report **[Б5]** from list of publications

*Lefterov E., **Avramova T.G.**, "Smoothing by sliding friction by an instrument with two hard elements and one movable working element", III International Scientific Technical Conference, Technics. Technologies. Edication. Safety, Proceedings, vol.3, Scientific technical union of mechanical engineering, (2015), стр.33-35, ISSN 1310-3946*

Known methods for smoothing the walls of holes by means of plastic deformation are currently: sliding friction and rolling friction. In the tools working by sliding friction is mainly used kinematic scheme based on one rectilinear motion.

Known observations of the operation of tools for machining deep holes show that the guide elements to some extent affect the microrelief of the treated surfaces. At a certain ratio of forces acting on the guide elements, it is possible to achieve an approximate roughness Ra = 0.4 μm. Conducted studies with a tool shown in the first part of the article confirms this statement and served as a basis for the development of a structure for smoothing existing holes with two fixed and one elastic support.

The second part of the article presents a developed design that has three smoothing elements with a certain shape of the contact area. Each individual element can be displaced relative to the others in the range of 20 °, which allows to create different friction conditions. The smoothing elements are pressed by a flat spring under one of the smoothing elements. Through it, various pressing forces can be applied to the walls of the hole. The area of entry of the tool into the machined hole is machined under a cone, and the angle is consistent with the diameter of the machined hole.

Experimental studies with the presented design were performed in the machining of steel S355 (used for the production of hydraulic cylinders) in the range of mode parameters, as follows: speed of rotation of the tool from 40 m/min to 140 m/min and speed of rectilinear movement from 0.035 mm/rev to 0.141 mm/rev. Various flat springs are used, the approximately calculated forces in the guide inserts not exceeding 2500N. Smoothing is performed in an oily medium fed freely through the central hole of the tool.

The results obtained for the quality parameters (size deviation, deviation from roundness and deviation from cylindricity) measured for a sample with a diameter of Ø40 mm after machining with the most favorable smoothing conditions are shown: V = 80 m/min and s = 0.14 mm/rev.

The analysis of the roughness obtained after measurement proves the obtaining of the smoothing effect as a result of the treatment with the combined tool for sequential impact.

The analysis of the obtained data on the from the size accuracy deviation, roundness and cylindricity and the constructed round diagrams shows that the obtained values vary in small limits and are small in value, which meets the requirements for parts from the type hydraulic elements: for machined inner diameter D = 40 mm the size accuracy deviation varies in the range of 40.013 ÷ 40.056 mm, the deviation from roundness is in the range of 0.010 ÷ 0.043 mm, and the deviation from the cylindricity varies in the range of 0.017 ÷ 0.035 mm.

Abstract of report **[Б6]** from list of publications

*Lefterov E., **Avramova T.G.**, "Research of the limit processes in machining of holes", XII International Congress Machines, Technologies, Materials, Section "Technologies", Proceedings, vol.1, Scientific technical union of mechanical engineering, (2015), стр.51-53, ISSN 1310-3946*

The load scheme is characteristic and defining each construction of a tool for machining holes and its study allows improving their design and performance characteristics.

The theoretical foundations of the research are based on deriving mathematical dependencies for the forces and moments loading the drills with replaceable inserts, and for the study of the force load mathematical dependences are derived for determining the forces acting in the guide inserts.

It is obvious that at present it is impossible to accurately determine the cutting force components Fx, Fy and Fz acting on the cutting inserts, as their direct measurement allows an error of more than 5%, which in itself prevents obtaining reliable optimal design variant. These features require the creation of a new approach based on the development of an experimental setup, through which to recreate certain rational constructive variants obtained in theoretical research.

The construction of the experimental setup proposed in the article contains the following elements: a body providing strength to the tool; a thin-walled element covering the longitudinal channels for supplying the coolant; face seal; cutting module carrying the cutting insert fixed with a screw. The support elements are movable relative to each other and are fixed with screws and a counter body. Two groups of experiments were performed using the experimental setup. In the first case, a tool without guiding inserts, with a diameter of Ø31 mm, in the machining of steel S355, with a cutting speed of 120 m/min has been studied. The second group of experiments has been performed by creating different combinations of changes in the angles ψ, δ1 and δ2, which in practice represent different constructive variants of drills with three cutting inserts. Theoretically obtained variants are selected in which the position of the intermediate insert is changed, and the condition S1≈S2> 1 serves as a criterion for evaluating the rationality of a certain variant.

Given the peculiarities of the analyzed constructions, the following conclusions can be made:

- The developed experimental setup allows to check in real conditions different constructive variants, both for cantilever mounted drills and for drills for deep holes (with guiding elements);
- In the case of drills with two cutting inserts without guiding inserts, the change of angle ψ leads to a change in the loading scheme, in particular the direction and magnitude of the equivalent force acting in the frontal section;
- Under certain conditions, the equivalent force tends to 0 N, which means that the forces that form it are balanced;
- In the case of drills with guiding inserts (for machining deep holes), angle ψ affects in the same way, and in combination with the arrangement of the guiding inserts (angles δ1 and δ2) can be developed constructions with the same coefficients of resistance relative to the two guiding inserts;
- In the case of drills for deep holes, the forces F1 and F2 acting in the guides and predetermining the contact phenomena with the walls of the machined hole can be directly influenced by changing the angle ψ.

Abstract of report **[Б7]** from list of publications

Avramova T.G., *Stefanov,G.D., "Combined tools for SPD with radial feed", Proceedings of XXVII international scientific and technical conference, ADP Sozopol, TU-Sofia, issue 3/224 (2018), page 48-52, ISSN 1310-3946*

As a finishing method, the application of surface plastic deformation (SPD) increases the quality of treated surfaces and improves their performance. In addition, a significant reduction in machining time is achieved compared to other finishing methods.

The combination of pre-treatment and finishing (cutting and SPD) leads to the application of combined tools for SPD. Conditions are created for increasing the productivity of the finishing while preserving the advantages of the SPD method.

The presented article shows the construction of the combined tool, which consists of a cutting and deforming module, each of which is shaped according to the requirements of the combined machining. The advantage of the proposed combined tool is that it can work both horizontally and vertically. It can be with a rotating or fixed support shaft (respectively a boring module). In all cases, the cutting module is pre-adjusted on a certain size using a device.

To determine the technological capabilities of the tool, an experimental study has been performed with cast iron parts, with pre-drilled holes. The machined hole has a diameter of Ø60H7. The prior boring and the combined machining are realized on a conventional lathe C11MB, where the tool is installed in a device placed on the cross slide of the apron. A batch of 50 blanks has been machined. They are bored sequentially at one set tool size and after controlling the roughness and diameter, a SPD is performed and again the control of the above quality characteristics.

The measurement of the accuracy of the hole diameter has been performed with an hole diameter measuring gauge, and the roughness check on the parameter Ra by profilometer-profilograph "TALYSURF-6".

Резултатите от измерването са обработени статистически с помощта на компютър и програма „BBSTAT". Получени са следните числени характеристики:

The measurement results have been statistically processed using a computer and the "BBSTAT" software. The following numerical characteristics were obtained:

	boring	SPD
scope, R	0,059	0,0578
arithmetic mean value, $\overline{X}$	0,031	0,0256
root mean square, S[X]	0,013	0,011
dispersion, S2 [X]	1,44	1,26
asymmetry, χ_1[X]	0,17	-0,795
excess, χ_2[X]	-323,33	-270,08

In accordance with the obtained numerical characteristics according to Pearson's criteria, a normal or logarithmic-normal distribution is proved.

It is obvious that after the SPD the dispersion field has narrowed approximately 1,2 times. The roughness has been improved from Ra = 3.8 ÷ 5μm to Ra = 0.5 ÷ 0.6μm, which cannot be ensured by the reaming applied so far.

Abstract of paper **[Б8]** from list of publications

Avramova T.G., *Approach in Determining the Geometric Parameters of the Cutting Tools by Modeling in Solidworks Environment, International Journal of Engineering Research And Management (IJERM), Volume-04, Issue-11, November (2017), pp. 1-4, ISSN: 2349- 2058*

The measurement of geometric parameters of the cutting tools is only possible in a static position (as a geometric body). Currently, the determination of working angles (in the process of cutting) is possible only through one approach related to its analytical determination. This paper proposes a new approach built into the SolidWorks environment.

To create conditions for measurements of working angles of the tools is developed 3D model of turning tool and 3D model of collapsible tool with two cutting inserts for making holes

Consecutively, all major and changing their positions working planes have been built as a result of the different working conditions of cutting. The modeling of the tool and the cutting process allows the angles to be measured at all points of the cutting edge. The spatial location of the cutting element is determined by the following parameters: Clearance angle ‑ α; Rake angle ‑ γ; Cutting edge angle ‑ κ_r; Cutting edge inclination ‑ λ; Distance of the initial diametrical plane of the tool to the researched point of the cutting edge. Taking into account the fact that in the cutting process the listed parameters influence each other and an analytical expression is not able to describe all the peculiarities that arise during the work. The most appropriate location of the cutting inserts can be determined only complex - in analytical and experimental method. The influence of the parameter h in the cutting process and the influence of the setting angle κr were studied experimentally.

The results of the virtual measurement of angles α_{oe} and γ_{oe} at different conditions of the cutting process and different values of the static geometric parameters of the cutting part, values for measuring of the changeable clearance angle along the cutting edge (in function of r) and the comparison between the theoretical results and the results obtained by modeling in SolidWorks environment are shown graphically.

As a summary of everything presented in this paper can be said that:

1. The developed graphical-analytical method allows to visualize the work of different cutting tool designs and their condition in the cutting process.
2. The used approach makes it possible to determine (measure) the working angles of the tool at different static angles and design parameters.
3. A comparison between the developed method and the analytically obtained results give a difference of less than 2%.

Abstract of paper **[Б9]** from list of publications

Avramova T.G., *Regarding the Choice of Tools for Machining of Parts with Complex Configuration, International Journal of Engineering Research And Management (IJERM), Volume-04, Issue-11, November (2017), pp. 5-8, ISSN: 2349- 2058*

Modern production based on automated machines requires high reliability of the technological process. The cutting tools are the weakest unit of the technological system.

This article gives a certain approach at choosing a tool group for machining of a particular part.

It begins with a description of the types of surfaces adjacent to the part with a complex configuration. From the analysis of the surfaces to be processed and allowance of machining is performed pre-selection of a group of tools, and then exploring their functional capability according to the following criteria: strength analysis; determination of deformations under real load.

To perform the analyzes, computer simulations of the selected cutting tools were carried out, the calculated loads being set and for each of them the following are valid: determination of load patterns; simulation analysis (in a SolidWorks environment); determination of stresses and deformations of cutting tools occurring in the processing processes.

Cutting forces were obtained experimentally and after data processing from a planned experiment were proposed as step models. The tools are loaded with the maximum forces of cutting for particular processing at modes allowing maximum labor productivity.

The results obtained for the determined stresses and deformations after computer simulation of the instruments (results are shown only for the most critical tools of all tested) are shown graphically.

At the end of the paper the following conclusions are made:

1. An approach is proposed to select tools that allow the determining of their functional abilities.
2. Determination of body deformations makes it possible to predict the accuracy of the processing, especially for designs with smaller body sections.
3. The results obtained show that during loads and stresses occurring during processing, the selected tools show weaknesses at the sharp edges in the insert attachment area and in the tool attachment area to the machine (the shank of the tool) which can not be avoided due to limitations imposed by the machines and processes for making the bodies of the metal-cutting tools.
4. For the most critical tools, maximum deformations were recorded with the following values: for milling cutter for surface profiling - 2.32 mm; For turning tool for complex internal contours - 0.05 mm; Multifunctional tool for drilling, boring, facing and external turning - 1.02 mm.
5. The results allows to take measures to increase accuracy by a certain setting of tool and optimizing processing program in CNC machines.

Abstract of paper **[Б10]** from list of publications

Avramova T.G., *Developing a Methodology for Calculating the Working Angles of Cutting Tools with Replaceable Cutting Inserts, International Journal of Engineering Research And Management (IJERM), Volume-05, Issue-1, January (2018), pp. 17-21, ISSN: 2349- 2058*

Depending on the complexity of the principal kinematics scheme and the ratio between the linear and angular velocities of the individual movements, they may be varied in both the character and complexity of the trajectory of the relative motion of the instrument and the workpiece. In general case, the real geometrical parameters during operation of the tool are not identical to the static either in magnitude or the direction of their dimension [8,9]. That is why it is necessary to establish a new system for determining the kinematic geometric parameters, considering the instrument not as a space geometric body in a resting position, but as an object carrying out a certain work movement on the work surface of the workpiece.

For a base point for determining the geometric parameters in the cutting process appear:

- The trajectory of the relative displacement of the cutting element of the instrument relative to the surface of the workpiece;
- The regularity of the deformation process during the chip forming and the direction of leakage of the separated chip on the contact surface of the front surface of the tool.

A fundamental requirement to the design of the tool is the ability of all the points on its major flank to perform unobstructed, in the cutting process, working movement on the trajectory of the relative displacement predetermined by the adopted principle kinematic cutting scheme. Basic geometric parameter predetermining the performing of the unobstructed working movement of the tool in the cutting process is the clearance angle.

According to the above described and with the help of graphical schemes for determining the kinematic clearance angle and clearance working angle of the tool, for determining the guiding cones of the vector of the actual cutting speed Vp and for determining the guiding cosines of the main cutting edge, a methodology for calculating working angles of cutting tools with replaceable cutting inserts based on derived mathematical dependencies have been created.

A tool for drilling holes Ø26 mm, working by the method of dividing the metal cutting layer, is subjected to a survey of geometrical parameters.

An approbation of the developed calculation methodology is conducted and the modifications of the above mentioned working angles, their relation with the static geometric parameters and their change along the length of the cutting edge are shown. The developed methodology allows to calculate the working angles in areas with a minimum cutting speed converging to "0" as it is at the center of a tool for machining holes. Also it allows to solve the following tasks of the designing of the cutting tools with a replaceable cutting part.

- to determine the spatial location of the insert places on the tool shank to provide a rational working geometry;
- to avoid areas from the active cutting edges of the tool where there would be unfavorable cutting and friction conditions;
- to determine the direction of the chip flow that would ensure its reliable breakage and transportation in open "V" grooves (especially for collapsible drills).

Development includes contributions in the part of the designing of the cutting part of collapsible tools and solving of forward and inverse problems at determining rational cutting geometry.The developed mathematical model is easily adapted to the creation of programs for automation design of collapsible tools with replaceable cutting part.

Abstract of paper **[Б11]** from list of publications

Avramova T., *Lefterov E., Determination of chip length compression ratio at one-edge drills, Fiability and Durability Journal, Editura "Academica Brancusi", Targu-Jui, Issue 2 (2018), pp.33-41, ISSN: 1844-640X*

The process of formation of the chip during drilling with drills with disposable hard metal inserts (DHI) is largely similar to the mechanism of formation of the chip during turning. This similarity is most pronounced at the moment of incision the tool in the metal and the accompanying deformation processes that occur as a result of the interaction of the tool with the workpiece material. However, it is necessary to take into account the specific features of the cutting process that characterize the drilling.

The presented article shows derived theoretical dependencies for determining the chip length compression ratio, which is influenced by the rake angle of the tool and the angle of displacement β. On the basis of the derived dependencies, theoretical studies and calculations have been carried out with the following: permanent feed s = 0.1 mm/rev, rake angle γ (°), varying in the range 0°÷5° and 10 values of the displacement angle β in the range 0°÷45°. Theoretical research has been conducted on steel X210Cr12, aluminum alloy AlCu4Mg1 and steel C45.

For determining of chip breaker and studying the change in the chip length compression ratio an experimental setup is created based on an SP586 lathe with a main engine output of 15 kW, a range of revolutions - 5÷2500 (s^{-1}), longitudinal feed - 0,01÷40,9 (mm/rev) and a cooling system (consumption 30 l/min). The experiment is carried out under the following conditions: feed s = 0,1 mm/rev, tool cutting edge angle χ_r = 85° and diameter of one-edge drill D = 16 mm. The tool orthogonal rake angle changes from -10° to +10°, the cutting speed from 50 m/min to 250 m/min.

The results of the experimental studies confirm the results of the theoretical studies. The difference in the data obtained is not more than 3%. The chip length compression ratio increases with the increase of the rake angle γ. The chip length compression ratio Ka depends on the plasticity of the machined metal. For more plastic metals, the chip length compression ratio Ka is greater and is a variable magnitude for a larger range of cutting speeds.

From the results obtained it can be concluded that the displacement angle β is influenced most by the type of the machined material and the rake angle γ. By increasing the rake angle γ, the displacement angle β increases.

From the parameters of the cutting conditions, the most significant influence on displacement angle β has the cutting speed V when its value is up to 120 m/min, after this speed Ka and β almost do not change.

Abstract of paper **[Б12]** from list of publications

***Avramova T.**, Lefterov E., Determination of plastic deformation coefficient for one-edge drills, Fiability and Durability Journal, Editura "Academica Brancusi", Targu-Jui, Issue 2 (2018), pp.42-50, ISSN: 1844-640X*

In the machining of metals, under the action of an external force applied by the tool on the treated metal, initially elastic deformations occur which rapidly pass into plastic. Because of the contact between the cutting tool and the workpiece arise stresses that form the deformation zone. They create conditions for shearing between the grains, such as those which are oriented at an angle of 45° to the shear plane relative to the beginning of the deformation.

For the quantification of the deformation in the cutting process, the similarity in the chip forming process is used as a process of sequential displacement of an element after element with the principle of determining the coefficient of plastic deformation ε. In the present study, mathematical dependences for determining the plastic deformation coefficient are presented. The same are used for theoretical research of steel CT80, steel C45 and brass.

To verify the results of theoretical studies, experimental ones were also conducted. For research the plastic deformation coefficient is created experimental setup based on an SP586 lathe with a main engine output of 15 kW, a range of revolutions - 5÷2500 (s^{-1}), longitudinal feed - 0,01÷40,9 (mm/rev) and a cooling system (consumption 30 l / min).

Both in theoretical and experimental studies, the coefficient of plastic deformation is similar in value. The conclusion that can be drawn is that with the increase of the rake angle, the coefficient of plastic deformation decreases. At small rake angles and high cutting speeds typical for tools with disposable hard metal inserts, the coefficient of plastic deformation ε varies from 2 to 4, and these values are much higher than the critical deformation for structural steels – $(2 \div 7).10^{-4}$, which ensures reliable chip breaking.

Abstract of paper **[Б13]** from list of publications

*Lefterov E., **Avramova T.**, Some peculiarities of cylindrical milling, International Journal of Modern Manufacturing Technologies, vol. X, No.1, June (2018), pp.63-68, ISSN 2067–3604*

The milling with cylindrical milling cutters is performed in two ways: conventional and climb. In general, when rotation of the tool and rectilinear movement of the workpiece are carried out in opposite directions, the milling is counter, and in the same directions – climb. Conventional milling has a wider application.

It is known that the thickness of the cut metal layer is variable, which causes the occurrence of some peculiarities of the cutting process. This requires a study of the chip parameters, also affecting the milling unevenness.

In the first part of the paper a methodology is developed on the basis of derived theoretical dependences for research the change of the chip thickness in different types of milling (conventional and climb). In the case of conventional milling, each tooth at the beginning of cutting begins to operate at a zero thickness of the cut metal layer, and when it is out, it is maximum. In case of climb milling, each tooth of the milling cutter first cuts a chip with a maximum thickness (a = max) when the tool enters and goes out with a chip thickness equal to 0 mm. By analyzing the theoretical dependencies, it can be concluded that the parameters of the cut metal layer during milling can serve as a basis for the study of the parameters of the cutting process.

The second part of the paper presents experimental researches. A 3D model of a monolithic milling cutter and a working environment was created to perform the experimental research. Modeling was done using SolidWorks software based on hybrid parametric modeling technology and a wide range of specialized modules. It creates fully realistic example models with or without limitations and is perfectly suited to solving the task. When simulating the operation of the tool in a particular working trajectory is obtained changing of the area of the chip for milling cutters with a diameter D=8; 15; 22 mm at different positions K_i of the cutting edge, expressed by angle φ.

Analyzing the theoretical dependences on the methodology presented in the first part of the paper, the following can be seen: the chip thickness (a_δ and a_ψ) increases with the increase of the feed rate s_z and the milling depth t and decreases as the diameter of the milling cutter D increases; Maximum chip thickness is obtained when using milling cutters with smaller diameter and work with a large depth t. Studies of change in the area of the chip shows indirectly loading the tool and can assess the moment of incision and exit of the milling cutter from the workpiece.

In conclusion, it may even be that: when machining channels with triangular milling cutters, apparently is working with the greatest load; theoretical dependencies and 3D modeling cannot assess the change in chip parameters as they do not take into account the changes occurring as a result of the deformation processes in the cutting zone; the thickness of the chip at a conventional and climb milling remained approximately the same assessed as a geometric figure.

Abstract of paper **[Б14]** from list of publications

Avramova T., *Unevenness at face milling, International Journal of Modern Manufacturing Technologies, vol. X, No.2, December (2018), pp.13-17, ISSN 2067–3604*

For simplifying the analysis of the trajectory of movement of the milling tool is considered the instantaneous state of an even rectilinear motion A and an even rotational motion B. There are two variants: B is movement of the tool and A is movement of the workpiece; B and A are movements of the tool.

The relative trajectory described by “M” located on a circle with radius r and rolling without slipping along a straight line occupies different positions M1, M2, M3 ... M6 defining different types of planar curves.

According to the approach described in the first part of the paper, to determine the type of relative trajectory, can be developed different and principle new milling methods, and to forecast a kinematic possibilities of new metal cutting machines. This approach allows at milling to determine the torques, the trajectories and their impact on the durability of operation of the tools, Obviously, the faster failure of the tools in the classical section of the cut metal layer (with varying thickness), and the constant maintenance of a uniform thickness of the chip.

In the second part of the paper a theoretical model is developed based on derived mathematical dependences, the ultimate goal of which is to determine the coefficient of unevenness in face milling.

The dependencies shown in the article give a new approach to work, which influences the obtaining of the chip area. It in turn has a direct effect on the average force and the maximum milling force, by means of which coefficient of unevenness can be calculated. The area of the chip varies depending on the type of machined material and additionally includes coefficients taking into account the physical and mechanical properties of the machined material.

In theoretical researches with a milling tool modeled with the help of the software product SolidWorks, a study of the chip area have been made, which is directly related to the evenness of machining. The analysis of the obtained chip area at different diameters and position of the cutting edge makes it possible to determine the instantaneous change of the cutting forces. This makes it possible to track the change in the coefficient of unevenness. The aim is to maintain a constant chip area, which leads to a reduction in milling unevenness.

Abstract of paper **[Б15]** from list of publications

Avramova T., *Tool for Machining of Blind Conical Holes by Surface Plastic Deformation, International Journal of Advancements in Mechanical and Aeronautical Engineering, Volume 5, Issue 2 (2018), pp.33-35, Electronic ISSN: 2372-4153*

Reliability of machine-building products is ensured by the quality of the surfaces of their parts. In this connection, the role of the technological methods for finishing is decisive. Methods are implemented to ensure the quality of the machined surfaces corresponding to the requirements for the exploitation properties of the surfaces.

Finishing of blind conical holes through surface plastic deformation (SPD) has specific difficulties, most often carried out by tools with radial feeding of the deforming rollers. The known constructions of tools for machining blind conical holes have a hard action without the possibility of adjusting the size which has to be set and also the deforming force.

The main purpose of the paper is to present a construction of a tool for machining of blind conical holes by SPD with radial feeding of the deforming rollers, where is possible to limit the longitudinal feed of the separator with the rollers, the adjustment of the size which has to be set, as well as adjusting and elastic application of the deforming force.

The principle of operation of the tool is described, as a machining with this tool with radial feed of deforming rollers can be accomplished by two schemes:

- Rotary motion and forced axial shift of the support cone, as a result of which the deforming rollers performs a radial feed;
- Rotary motion of the workpiece and forced axial shift of the support cone, as a result of which the deforming rolls perform a radial feed.

The choice of the machining scheme depends on the construction of the workpiece. The second scheme is applicable to rotational parts and to those which do not cause dynamic loads in its rotation.

For checking the technological capabilities of the tool are machined pre-experimental workpieces with conical surfaces – 6 pcs with a large diameter of 45 mm and a length of 50 mm. The blanks are made of solid bronze material (CuSn10Pb10) pre-drilled and bored. The machining is done on a universal lathe C11M. The roughness was measured by the TALYSURF 6 measuring device according to the Ra and Rz parameters. The fluctuation for Ra is in the range of 0.28 to 0.18 μm, for Rz from 1.4 to 0.9 μm. Accuracy is achieved by pre-treatment and after SDP is controlled by a grinded conical mandrel.

Combining the capabilities of the tools with radial feeding with the advantages of the elastic application of the deforming force contributes to the obtaining of a layer with homogeneous physical-mechanical properties. Compared to the known solutions of the problem, the proposed design allows to improve the physical-mechanical properties of the treated surfaces and their respective performance characteristics, and the presence of a large number of parts with conical holes with small angles of cone in the machine-building is a prerequisite for its implementation.

From the description of the proposed tool it can be concluded that its advantages over the known designs consist in the possibility of limiting the longitudinal feeding of the separator with the rollers, in the possibility of elastic applying of the deforming force, in the possibility to adjust both the size and deforming force.

Abstract of paper **[Б16]** from list of publications

Avramova T.G., *Some Aspects Of Designing Cutting Tools, Eastern Academic Journal, Issue 1 (2018), pp. 79-85, ISSN: 2367-7384*

Cutting tools are seemingly not a complex technological system, but considering the conditions of their work can separate some specific elements: ensuring their reliability, including long-term work and quality ensuring after processing; features of the power and heat load of the cutting part and their body.

These features are particularly characteristic of non-monolithic tools with mechanical attachment of the cutting part.

It is not possible to perform any engineering calculation without knowledge of the mechanical properties of engineering materials used. The main physical and mechanical properties of the material for making the body of the tool and the cutting insert are shown in the development. Another significant mechanical characteristic is the fatigue limit σ_{-1} determined at the symmetric cycle and σ_r - defined at an asymmetric cycle. It represents the greatest tension at a cyclically varying transverse state in which the material can practically endure endlessly many cycles. Based on these input data, the paper presents an approach for strength analysis of the individual monolithic elements of the construction of cutting tools, which takes into account the change of physical and mechanical properties of the materials used for the manufacturing depending on operating temperatures. In this way the reliability of the non-monolithic tools with mechanical fastening of the cutting part is guaranteed.

For the practice, the thermal load and creep of the fasteners (screws) fastening the inserts in the body of the tool are of particular importance. Upon slow heating of the carbon steel has three stages of conversion as follows: from 30÷200°C – first, 200÷300°C – second and from 300÷450°C third conversion. The significant values obtained in experimental reseraches and given in the paper show that a sharp deterioration in the physical and mechanical properties of the fastening element and deterioration of the reliability of the screw joint may be possible.

Based on the results of the experimental reseraches on the heat load and the creep of the fasteners (screws), the following conclusion can be made: usually fixing screws are used repeatedly in several changes of the inserts, which leads to risk at work. The curve of creep and fatigue brought into development confirms a similar finding. Perhaps the weakest part is the threads of the thread, which, as it is known, have the smallest sections and the fastest they heat up.

The analysis shows that at the design of the individual elements of non-monolithic tools is necessary to take account of the stresses and deformations caused by the force load and thermal load.

Abstract of paper **[Б17]** from list of publications

Avramova T.G., *Lefterov E.L., Influence of the Shape of the Tool Bodies For Machining Holes in Strength Calculations, Eastern Academic Journal, Issue 1 (2018), pp. 86-94, ISSN: 2367-7384*

The total load of the structure of various drills resulting from the forces occurring in the cutting zone. The absence of guiding elements allows with a certain approximation, the tools to be considered as fixed at the one end beams with a complex shape.

For single-sided drills, the forces can be decomposed into components lying in two mutually perpendicular main inertial planes. Although the position of the cutting insert, the one-sided drills are primarily loaded with torsion, and the cutting edge angle kr has a strong influence on the radial load. The loading of the double-sided and annular drills is more complicated due to the presence of two cutting inserts. The application points of the cutting forces are generally not in plane YZ. The components of the cutting forces and the moments acting on the structure are aligned with the YZ coordinate system.

Based on the analysis of the total load of the construction of one-sided, double-sided and annular drills with replaceable inserts made at the beginning of the paper, a methodology for strength calculations of drills with replaceable carbide inserts has been developed. For strength calculations, it is necessary to evaluate all the individual parts: the cutting part, the body and the connecting part.

For each type of drills, the coordinates of the mass center, the static moments and the position of the main inertia axes and moments are consistently determined. The basic schemes for their determination and the derived mathematical formulas are shown in the paper.

Based on the developed methodology and its analysis, the following summaries can be made:

- For the accurate strength calculation of tools for machining of holes, it is necessary to use a load taking into account differences as the cutting conditions for the central and peripheral insert.

- In strength calculations of the cutting insert the contact loads on the face and the major flank must be used.
- Strength studies of the bodies of the tools requires to optimizing of the design from the point of view of the shape.
- Applying in full on numerical calculation methods does not accurately assess the stresses and deformations obtained (not shown in this paper). The error in some cases exceeds 10%, which requires a classic approach for calculating beams with variable cross sections.

Abstract of paper **[Б18]** from list of publications

Avramova T.G., *Kinematics of the cutting process with complex imposed vibrations during machining of holes, Eastern Academic Journal, Issue 1 (2018), pp. 62-69, ISSN: 2367-7384*

The processes of drilling and machining of holes with tools having guiding smoothing supporting elements can greatly alleviate if in technological system are applied to the tool or workpiece complex imposed vibrations.

This paper examines a new, more complex case of combining the imposed vibrations with their use specifically for drilling and smoothing the machined holes.

The specificity of the process consists in the additional setting of the tool to axial and rotational oscillations simultaneously, resulting in a change in the primary and the feed motion.

The vibrations are set by a hydraulic vibrator mounted on the tool body allowing changing the frequency and amplitude of the oscillation as well as the removal of one or the other vibrational movement or combining them.

In order to apply the new kinematic scheme, its theoretical description is first made (by means of appropriate derived mathematical formulas).

The proposed construction of a vibrator for simultaneously setting the axial and rotary oscillations is a hydraulic vibrator built on the basis of thin-walled steel pipes.

The device comprises a body and cover, between which is mounted a vibrating element. In the space between the vibrating elements, body and cover there are mounted thin-walled steel tubes arranged two by two oppositely in two mutually perpendicular planes. The tubes are pressed by means of pins to the vibrating element and to the body by means of screws having a conical forming line at its tip.

The hydraulic vibrator operates in the following way: the vibrator is rigidly secured to the clamping device of the machine by means of a conical or cylindrical tail. In the conical or cylindrical hole of the vibrating element, is mounted the cutting tool. The piston pump is free of pressure valves, which allows after each injection the pressure to falls to zero atmospheres and enables the system to be closed.

Upon supplying a pressure impulse from section A of the piston pump, fluid is fed to two of the thin-walled tubes which swell elastically and rotate the movable part of the vibrator counterclockwise and provide axial displacement to the left. At this point, the opposite tubes do not swell elastically due to the absence of a pressure impulse therein.

Upon submitting a new pressure impulse from the section C the fluid is fed to the next two thin-walled tubes whereby the movable part of the vibrator receives a clockwise rotation and axially displaced to the right. Thus, for one revolution of the pump, four linear displacements and four turns are obtained.

In conclusion of all the above it can say the following:

- A theoretical methodology has been developed to describe a new kinematics scheme containing two additional displacements having a cyclic nature.
- - Dependencies are derived for calculating the change in thickness of the chip removal and the working clearance angle αoε.
- - A hydraulic vibrator construction has been developed to implement the developed kinematics scheme.
- - Vibration amplitude adjustment is carried out by varying the fluid pressure, and the frequency is varied by changing the pump speed.

Abstract of paper **[Б19]** from list of publications

Avramova T.G., *Designing of annular drills with the direction of the internal residual stem, Eastern Academic Journal, Issue 1 (2018), pp. 90-98, ISSN: 2367-7384*

The designing of annular drills is predetermined by the design features requiring reliable guidance in the cutting process (Лефтеров, Николов, 1989). This requires the development of a specific design methodology.

Developed in this article methodology for constructing is divided into three main steps.

The first step in designing the tool is related to determine operating scheme that directly affects its construction. It is determined by the kinematic cutting scheme and the scheme of shaping (Лефтеров, 2017). The kinematic cutting scheme and the cutting of the allowance of machining is shown in the note to the paper. According to the method of obtaining the annular profile, two principal schemes of shaping "profile" and "sequential" can be used. In this case, the scheme is sequential.

The second step in the design is related to the choice of materials for making the tool. The tool is made from several parts and therefore its individual parts are made of AISI 5140 or AISI1045 steel, and the cutting inserts may be depending on the machined material P, M or K. The structure under consideration has been developed with three three-sided inserts type TNUM having chip breaking elements on the face surface of the type – WM or – MM. The guiding movable rollers are hard metal pins of the material P10.

In the third step in the construction is performed balance of the cutting forces and determining the locations of the guide rollers in order to achieve a sustainable equilibrium of the tool.

The force system acting on the design of the annular drill includes not only the forces required for chip forming and acting in the contact zones on the face and major flank of the cutting inserts but also the forces acting on the support rollers. The scheme of loading of the annular drill is described mathematically with the dependences deduced by the author.

To obtain results from the designing of a annular drill with a diameter D = 80mm for machining structural steel, the dependencies from the theoretical part of the article for determining the forces F_1 and F_2 and the formulas of the four variants of the angles δ_1 and δ_2 are used. After the calculations made it has been found that the drill has the highest stability in the first variant, with the support rollers placed at angles δ_1=110 ° and δ_2=225 °.

The conclusions from the above are the following:

1) The created method with small additions enables the designing of any type of annular drills not only on the basis of interchangeable inserts;

2) From the scheme of cutting the allowance of machining with sequential positioning of the cutting inserts a significant reduction of the force loading can be achieved by:

- Using of inserts with a shorter length of cutting edge;

- Using different value cutting edge angles.

3) By changing the angle κ_{ri} can reduce the components P_y and in this way to change the ratio between F_{hor} and F_{ver}. Here it is necessary to consider the stage of incision and formation of the leading cone at the bottom of the machined technological section.

4) At angles κ_r close to 90° axial load increases and increases the susceptibility of the technological system.

5) From a construction point of view, it is often necessary to find a compromise in the positioning of the support rollers in order to axially secure the modules bearing the cutting inserts and the fastening elements.

6) Upon basing on the internal residual stem, rollers operating at friction by rolling are used.

Abstract of report **[Б20]** from list of publications

Avramova T.G.,*"Study of design of turbocharger compressor wheel using SolidWorks Flow Simulation" Eastern Academic Journal, Issue 3 (2018), pp. 111-121, ISSN: 2367-7384*

Nowadays, car manufacturers have to comply with very strict requirements for environmental friendliness, safety, economy, power and comfort. With ever stricter emission standards and the demand for smaller and at the same time more powerful engines, it can be seen that turbochargers (the so-called "Turbo") play an increasingly important role. This is the reason for constantly working in the field of development of turbochargers in the direction of its continuous improvement and further increase of power. One way to increase power is to change the design of the turbocharger compressor wheel. Engineers are helped here by various software products for analysis, which would provide information on how the required parameters are modifying when changing the design of the compressor wheel, without the need to invest a lot of money for the real producing of all possible constructions and their study. The present article proposes a study of a non-standard turbocharger compressor wheel design to increase power using SolidWorks Flow Simulation.

Before proceeding with the theoretical simulation research, the following two tasks have been performed: the compared constructions of the compressor wheels have been modeled in the environment of the software product SolidWorks (the most important features in the designing and the difference in construction of the two wheels are described; so-called "Trim" (longitudinal inclination) of the turbine and compressor wheel have been calculated.

For conducting fluid analysis it is necessary to create a simplified model of the so-called. "Compressor spiral" of the selected model turbocharger "GT2860R" in basic dimensions from the manufacturer "Garrett" and the corresponding calculations are made. After performing the two fluid analyzes, a comparison have been made between the results obtained. This makes it possible to verify (confirm) the positive influence of the improved geometry of the compressor wheel on the power of the turbocharger.

As a summary of the results of the analysis it can be said that the power of the modified compressor wheel is about 12% higher than the power of the turbocharger with a compressor wheel with a standard design and confirm the great contribution that software products such as SolidWorks Simulation Flow have in reducing costs in the design stage, testing and analysis of various objects, as well as accelerating the production process of the same.

Abstract of report **[Б21]** from list of publications

Avramova T.G.,*"Designing of portable router machine with computer numerical control" Eastern Academic Journal, Issue 4 (2018), pp. 239-252, ISSN: 2367-7384*

Router machines with computer numerical control are computer-controlled machines for machining various parts, which work in a Cartesian coordinate system (X, Y, Z) for 3-dimensional motion control. CNC routers are characterized by the fact that they improve the quality of the produced parts and increase the productivity. To control a CNC router, it is necessary to select the appropriate software product. Currently, there are various types of different manufacturers, paid or free, which turn the personal computer into a fully functional CNC system. The job of the software is to convert the code from the control program into a pulse signal that controls the movement of stepper or servomotors. This article presents a methodology for designing a CNC portal router machine.

The article is mainly divided into two parts: in the first part of the design methodology describes the selection of the necessary main components that participate in the current construction. The dimensions and material of each component are described. The second part of the methodology shows the modeling of the basic components in the software product SolidWorks, explaining in detail the construction, dimensions and materials of the components. The method of assembling a portal router machine with CNC is described, and at the end of the article is shown the finished produced and assembled machine.

Представената в настоящата статия методика за проектиране на портативна рутерна машина с цифрово програмно управление е подходяща за бързо и лесно изработване на такъв тип машина за непрофесионално използване или използване в единично производство, където този вариант рутерна машина е икономически изгоден и не оскъпява допълнително изработената с нея продукция.

The methodology presented in this article for designing a portable router machine with CNC is suitable for quick and easy production of this type of machine for non-professional use or use in single production, where this variant router machine is cost-effective and does not increase the price of the production made with it.

The portable CNC router machine performs all the functions performed by the router machines known on the market, differing only in the power and overall dimensions of the machined parts.

Abstract of report **[Б22]** from list of publications

*Georgiev, D.S., Slavov, S.D., **Avramova, T.G.**, "On the methodology for determination of features of regular microshape", Journal "MTT", b.2, issue of TO of NTS-Varna and TU-Varna, 2010, pp.3-5, ISSN 1312-0859*

Surfaces with regular micro relief (RMR) are of interest due to the influence they have on the tribological properties of the surfaces of the parts. This is one of the reasons to look for methods for their measurement and standardization. RMR have roughness parameters that are qualitatively different from the parameters of surfaces treated by standard finishing methods - fine turning, fine milling, grinding, etc. These features of the RMR require special methods of measurement and classification (formed as a standard for measuring the roughness), as in the standard methodologies existing in the known standards for measuring the roughness of the workpiece they are not applicable.

The presented article analyzes four methods for measuring and determining the parameters of the roughness of RMR: standard GOST 24773 - 81, the method of long profilograms, measurement method according to BDS EN ISO 4287: 1998 / A1: 2009 and a method for three - coordinate measurement.

The analysis of the four methods for measuring and determining the roughness parameters of PMP shows that a standard methodology for adequate measurement and standardization of the roughness parameters of RMR has not yet been developed.

However, the methodologies № 2 and № 4 give results that are close to the objective values of the RMR, but they do not give the accuracy and adequacy of the measurement expected from a good methodology.

Based on the methodologies № 2 and № 4, a new methodology should be developed, which would combine the approach for determining the parameters of a cell from RMR (from methodology № 4) and unfold it on the entire treated surface (from methodology № 2).

The new methodology should be developed as a basis for a new standard that takes into account all the features of the shape, size and location of RMR cells and provides measurement, calculation and standardization of the roughness parameters of this specific type of micro relief.

Abstract of report **[Б23]** from list of publications

*Stoyanova A.M., Bakalova M.I., Mechkarova T.M., **Avramova T.G.**, "Methodology for experimental-statistical study of interaction between the technological process parameters of air-plasma cutting", Journal "MTT", b.2, isuue of TO of NTS-Varna and TU-Varna, 2010, pp. 81-85, ISSN 1312-0859*

The main goal of the present study is to establish the technological capabilities of the method for air-plasma surface cutting with combined equipment for plasma cutting and surface cutting Powermax G3 and to optimize the mode parameters experimentally using the methods of experimental planning and mathematical statistics.

The research begins with clearly set tasks at the beginning of the article. The material for which the study is conducted is medium carbon steel C45 with thickness $\delta=8.10^{-3}$ m. The research has been conducted in the laboratory "Technology of welding production" at TU-Varna. The experiments have been performed with an experimental Airmax G3 air-plasma surface cutting system. In the experimental-statistical study of the relationship between the technological parameters of the process of air-plasma surface cutting of metals the following sequence is observed: planning the experimental study, conducting sequentially all experiments of the selected plan, statistical processing of experimental data, compiling a mathematical model and verification of its adequacy, optimization of the initial parameter, graphical analysis of the regression model and study of the influence of the thickness and type of the cut material on the speed of surface cutting.

An experimental plan is selected for three factors with twenty attempts, with the help of the software product MathCAD the data from the plan are processed, the adequacy of a mathematical model is checked by Fisher's test, the graphical analysis of the regression model is performed by processing statistical data using the software MATLAB, the microscopic observation of the surfaces of the channels after plasma surface cutting was performed with NEOPHOT 32 with a magnification of 1.25x8 = 10 times and a magnification of 2.5x8 = 20 times at different sample thicknesses with the same operating modes.

Based on the research done, the following conclusions can be made:

- The most important factor for the plasma surface cutting speed Vp is the current I. The mathematical model shows that the change in the current I leads to a monotonic and directional change in the cutting speed Vp.
- The next most important factor for the surface cutting speed Vp is the distance "nozzle-metal" h, and in the area of the optimum its significance is about 90% of that of the current I.
- A factor that has a minor effect on Vp is the consumption of plasma-forming gas Qг. In the area of the optimum, which is a local maximum for it, its importance for the cutting speed Vp is approximately insignificant.
- The performed microscopy analysis shows the high quality of the surfaces after the surface plasma cutting, which is the main goal in this type of treatment.

Abstract of report **[Б24]** from list of publications

*Lefterov E., **Avramova T.**, "Study of the force load in drills with asymmetric scheme of cutting the allowance of machining" Proceedings of union of scientists – Varna, Series of Technical sciences, vol.1, Union of sciences – Varna, 2014, pp.55-58, ISSN 1310-5833*

The application of replaceable inserts (RI) in different constructions of hole machining tools leads to asymmetric cutting schemes of the allowance for machining. Such tools are those with one, two or more cutting inserts for machining the normal and deep holes. This feature causes the presence of an equivalent force that acts on the body of the tool and the spindle assembly of the machine tool or through the guide elements of the technological system as a whole.

The load scheme is characteristic and defining each construction of a tool for machining holes and its study allows improving their design and operational characteristics.

The basics of the research begin with the derivation of theoretical dependencies, which represent the forces and moments loading drills with replaceable inserts.

At present, it is impossible to accurately determine the cutting force components Fx, Fy and Fz acting on the cutting inserts, as their direct measurement allows an error of more than 5%, which in itself prevents obtaining a reliable optimal constructive variant. These features require the creation of a new approach based on the development of an experimental setup, through which to recreate certain rational constructive variants obtained in theoretical researches.

The general appearance of the tool representing the experimental setup is shown and explained in the article. Two groups of experiments have been performed using the experimental setup. In the first case it has been studied a tool without guiding inserts with a diameter of Ø31 mm, in the machining of steel S355, with cutting speed 120 m/min. The second group of experiments has been performed by creating different combinations of changes in the angles ψ, δ_1 and δ_2, which in practice represent different constructive variants of drills with three cutting inserts and guiding inserts.

Given the peculiarities of the analyzed constructions and the obtained results, the following conclusions can be made:

- The developed experimental setup allows to verify in real conditions different constructive variants, both for cantilever mounted drills and for drills for deep holes (with guiding elements);
- In the case of drills with two cutting inserts without guiding plates, the change of angle ψ leads to a change in the load scheme, in particular the direction and magnitude of the equivalent force acting in the frontal section;
- Under certain conditions, the equivalent force tends to 0 N, which means that the forces that form it are balanced;
- For drills with guiding inserts (for machining deep holes) angle ψ affects in the same way, and in combination with the location of the guiding inserts (angles δ_1 and δ_2) can be developed constructions with the same coefficients of resistance relative to the two guiding inserts;
- In the case of drills for deep holes, by changing the angle ψ it can directly affect the forces F_1 and F_2 acting in the guiding plates and predetermining the contact phenomena with the walls of the machined hole.

Abstracts of papers from group [B]

Abstract of teaching tutorial **[B1]** from the list of publications

*Nedelchev D., **Avramova T.**, Mechanical Engineering Technology - Part I, Guide for laboratory exercises, TU-Varna, Varna, 2013, p.143, ISBN 978-954-20-0572-8*

In this guide are published the methodologies for conducting laboratory exercises in the discipline "Mechanical Engineering Technology Part I" included in the curriculum of the specialty ”Manufacturing engineering and technologies" at TU-Varna. They expand and deepen students' knowledge obtained from lectures on discipline.

The material for each exercise contains: the purpose of the exercise, a short theoretical statement, the order conduction of the exercise with instructions for conducting laboratory tasks, instructions for the content and preparation of the protocol of the exercise. In the separate exercises are described schemes of the experimental setups, the used equipment, devices and tools.

In preparing the exercises, the still incomplete foundation of students' knowledge in their studies and the existing material base of the TMMM department of TU-Varna are taken into account.

The guide can also be used for conducting exercises in the disciplines "Mechanical Engineering Technologies" and "Production Technologies" included in the curricula of other specialties from TU-Varna.

Abstract of teaching tutorial **[B2]** from the list of publications

*Lefterov E., **Avramova T.**, Design of technological equipment, TU-Varna, Varna, 2017, p.112, ISBN 978-954-20-0769-2*

This textbook provides information on the types of machine devices and tooling used in the field of mechanical engineering. It is designed for students studying in the field of mechanical engineering and specialists from industry

The textbook is developed in two main sections. The first section deals with machine devices, including devices for fixing and fastening, clamping mechanisms, drive of technological devices, magnetic devices, standard reusable devices, etc. The second section discusses the tooling, which includes auxiliary devices for turning, milling and drilling with CNC, tool blocks, self-propelled devices and others.

The development allows designing, selecting and recommending the main types of technological devices and tooling.

Abstract of teaching tutorial **[B3]** from the list of publications

*Lefterov E., **Avramova T.**, Cutting materials - Guide for laboratory exercises, TU-Varna, Varna, 2018, p.101, ISBN 978-954-20-0781-4*

The guide has developed 11 topics for laboratory exercises, which reflect some of the main sections of the studied lecture material in the discipline "Cutting materials". The necessary methodologies, installations and measuring tools for conducting laboratory exercises and methodologies for processing the obtained results are shown.

Ръководството е предназначено за студентите, обучаващи се в направление „Машинно инженерство" и направление „Общо инженерство".

The guide is intended for students studying in the field of "Mechanical Engineering" and the field of "General Engineering".

Abstracts of papers from group [Г]

Abstract of utility model **[Г1]** from the list of publications

*Lefterov E., **Avramova T.**, "Combined tool for expanding holes", Patent Office of the Republic of Bulgaria, Utility model BG 2989 U1, 12.09.2018*

The utility model refers to a combined tool for expanding holes, working by removing thin layers of metal and at the same time for smoothing by sliding friction. The tool will find application in mechanical engineering, in particular in the production of parts with precise holes.

The purpose of the utility model is to be created a combined tool for simultaneous expansion and smoothing of holes with three supports, working as cutting-smoothing elements. They are designed to simultaneously remove chips and smooth the machined surface by sliding friction.

The contact forces are changed by changing the angles of mutual arrangement of the individual movable working elements.

The body of the tool is a thick-walled tube on which is machined a stepped section for mounting the working elements.

The guiding cutting and smoothing elements are sector parts that have three contact sections each. The stationary element is fixed to the body by means of two screws and a counter body. The other two movable elements are fastened in the same way. The working elements have inner and outer cylindrical generatrix the inner one coinciding in diameter with the stepped section for fastening, and the outer generatrix having a diameter depending on the machined hole.

The rotation of the guides is due to the presence of four diametrically arranged channels.

The cutting-smoothing guiding elements have helical grooves at an angle of 30° or 60°, as well as a cutting angle of 2°. The coolant is fed into the gap between the body and the machined hole.

The working elements are made of metal ceramics, and each of them can be made of different hard alloy, shape (circumscribed radius) and dimensions according to the requirements for accuracy and roughness of the machined holes.

Abstract of utility model **[Г2]** from the list of publications

Lefterov E., ***Avramova T.****, "A tool for plastic deforming of internal cylindrical surfaces", Patent Office of the Republic of Bulgaria, Utility model BG 2994 U1, 28.09.2018*

The utility model refers to a tool for machining holes by means of plastic deformation performed by sliding friction. The tool will find application in mechanical engineering, in particular in the production of hydro and pneumatic elements.

The purpose of the utility model is to be created an adjustable tool for smoothing holes with three deforming elements, working by the method of friction by sliding.

The aim is achieved by the proposed according to the utility model tool for plastic deforming of internal cylindrical surfaces, consisting of a cylindrical body ending in a conical or cylindrical tail, to which are mounted three guiding-smoothing elements, one of which is fixed and the other two - movable. The body of the instrument is a thick-walled tube, on which a stepped section is machined, along the cylindrical generatrix of which, four sector channels and two holes are machined. The four sector channels are positioned in two diametrically arranged pairs. The fixed guiding-smoothing element is mounted to the two holes by two screws and a counter body. The two movable guiding-smoothing elements are mounted to the two pairs of sector channels, with two screws and a counter body. The three guiding-smoothing elements are sector parts with cylindrical generatrix and conical part in the front, which have three contact surfaces each. The elements are made of metal ceramics, and each of the three contact sections can be made of different hard alloy, shape (circumscribed radius) and dimensions according to the requirements for roughness and accuracy.

To change the forces acting in the guides, the change of the spatial system of forces occurring at different angular position of the movable smoothing elements compared to the fixed one is used.

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